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METHOD FOR PRODUCTION OF WATER-ABSORBENT COMPOSITE MATERIAL

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[There are no amendments to this patent.]

Claims

1. A method for production of a water-absorbent composite material characterized by adsorbing a mixture comprising an aqueous solution of monomer containing an alkali metal salt of an acrylic acid and a divinyl-based compound and a photosensitizer composed of a water-soluble azo compound containing an amidino group onto a base material and polymerizing and cross-linking the aforementioned mixture by irradiating with ultraviolet rays.

2. The method for production described in Claim 1 of the invention, characterized by the fact that an aqueous solution of a cross-linking agent is further adsorbed after polymerizing and cross-linking the aforementioned mixture by irradiating with ultraviolet rays.

Detailed explanation of the invention

Industrial application field

The present invention pertains to a novel method for production of a water-absorbent composite material.

Prior art

A water-absorbent composite material is composed of a variety of base materials such as a nonwoven fabric, absorbent cotton, paper pulp, a synthetic resin foam and a sponge, and water-absorbent resins such as acrylate-based, cross-linked polymer materials. Water-absorbent composite materials are widely used for sanitary products, for example, medical sheets, sanitary napkins and other sanitary products, such as disposable cleaning cloths, as well as for agricultural products such as water retainers, and in applications for the prevention of condensation of dew on building materials, for dehydration of oils, for the coagulation of sludge, etc.

Known methods used for production of water-absorbent composite materials in the past include (1) a method consisting of impregnating a base material with a water-absorbent resin made of a cross-linked polyacrylate obtained as a result of a thermal polymerization reaction, and impregnating by a means such as dispersing and mixing (Japanese Kokoku Patent No. Sho 61[1986]-23016), and (2) a method consisting of impregnating a paper or fabric-like material with a raw material solution formed by adding a radical initiator to an aqueous solution of a monomer mainly comprising an acrylic acid, followed by providing a thermal polymerization reaction and drying (Japanese Kokai Patent Application No. Sho 61[1986]-55202), etc. However, each of the aforementioned methods is accompanied by problems.

That is, when the aforementioned method (1) is used, degradation of the working environment as a result of airborne powder of the water-absorbent resin at the time of spraying, etc., poses a problem, because the water-absorbent resin is applied to the base material using a method such as a scattering process. Furthermore, adhesion between the base material and the water-absorbent resin is likely to be insufficient, in which case problems such as desorption and localization of the water-absorbent resin are likely to occur, and maintaining the initial water-absorbency cannot be expected. On the other hand, in the case of the aforementioned method (2), the polymerization yield of the monomer is likely to be reduced; thus, in order to increase the polymerization yield and to obtain a composite material essentially without any non-reacting monomer, use of an aqueous solution of a monomer at a high concentration is required. In this case, the base material is exposed to a high temperature as a result of the sudden temperature increase that occurs during the course of the polymerization reaction, and as a result, applications of the base material are limited. Furthermore, the monomer is impregnated; thus, a polymerized material is formed over the entire surface of the base material, and softness, air permeability, etc., of the composite material, are reduced or the surface area of the resin is reduced, and as a result, the water-absorbency of the composite material itself is likely to be reduced.

Problems to be solved by the invention

The primary objective of the present invention is to provide a novel efficient and high-yield method for production of a water-absorbent composite material having excellent softness and air permeability as well as high water-absorbency.

Means to solve the problems

Based on the above background and in order to achieve the aforementioned objective, much research has been carried out by the inventors of the present application, especially on the development of a polymerization reaction method comprising an aqueous solution in the production of an acrylate-based polymer cross-linked material by a novel method utilizing ultraviolet rays and on the use of the aforementioned method in the production of a water-absorbent composite material. As a result, it was discovered that the aforementioned objective could be achieved when a specific photosensitizer was mixed with an aqueous solution of a monomer containing an alkaline metal salt of an acrylic acid and a divinyl-based compound, and the aforementioned mixture was adsorbed onto a base material and exposed to ultraviolet rays. The present invention was achieved as a result of the above discovery.

Thus, the present invention is a method for production of a water-absorbent composite material characterized by adsorbing a mixture comprising an aqueous solution of a monomer containing an alkali metal salt of an acrylic acid and a divinyl-based compound and a photosensitizer composed of a water-soluble azo compound containing an amidino group onto a base material, and polymerizing and cross-linking the aforementioned mixture by irradiating with ultraviolet rays.

In the present invention, the primary monomer unit used for the water-absorbent resin included in the water-absorbent composite material is an alkaline metal salt of an acrylic acid. In this case, the alkaline metal salt used is either a sodium salt or a potassium salt. The aforementioned alkaline metal salt is formed by neutralizing an acrylic acid with sodium hydroxide or potassium hydroxide, and it is not necessary for the aforementioned material to be a completely neutralized, so a partially neutralized material may be used; in general, the degree of neutralization is preferably in the range of 50-100%. That is, when the degree of neutralization is below 50%, the water-absorbency of the water-absorbent resin is likely to be reduced.

Furthermore, the aforementioned divinyl-based compound used in combination in the present invention as the other monomer is included to provide a cross-linking structure to the water-absorbent resin formed by copolymerizing and cross-linking with the aforementioned alkaline metal salt. As desirable divinyl-based compounds that can be used in this case, for example, divinylbenzene, N,N'-methylene bisacrylamide, N,N'-methylene bismethacrylamide, polyethylene glycol diacrylate, polypropylene glycol diacrylate, etc., can be mentioned, and the

aforementioned monomers can be used independently or in combination. The amount of the aforementioned divinyl-based compound used in this case is appropriately determined by considering such factors as water-absorbency of the water-absorbent resin obtained and the degree of gelation, but in general, an amount in the range of approximately 0.001-5.0 wt%, preferably in the range of 0.005-0.5 wt%, is suitable. When the aforementioned amount used is less than 0.001 wt%, the degree of gelation is likely to be reduced; on the other hand, when the amount exceeds 5.0 wt%, the water-absorbency is likely to be reduced, and either case is undesirable. Furthermore, in addition to the aforementioned essential alkaline metal salt of an acrylic acid and divinyl-based compound required in the present invention, acrylamide, acrylamide-2-methylpropane sulfonate, lower acrylates, methacrylic acid, etc., may be added as needed, and when factors such as water-absorbency, water retention and gel strength are taken into consideration, the amount of the aforementioned optional material used is approximately 20 wt% or less for the total amount of monomer.

In the present invention, use of a specific photosensitizer, that is, a water-soluble azo compound containing an amidino group, is essential. The aforementioned azo compound satisfies the polymerization reaction rate, radical formation temperature, solubility in an aqueous solution of the monomer, etc., at the time of solution polymerization of the aforementioned monomer with ultraviolet rays. As specific suitable examples of the aforementioned compound, 2,2'-azobis(N,N'-dimethyleneisobutylamidine)-2-hydrochloride, 2,2'-azobis(2-amidino propane)-2-hydrochloride, 2,2'-azobis(N,N'-dimethyleneisobutylamidine), etc., can be mentioned, and one or more of the aforementioned compounds can be used in this case. The aforementioned azo compound functions as a photosensitizer as well as a thermal polymerization initiator in the present invention. Furthermore, as photosensitizers commonly used for ultraviolet-ray polymerization reactions, diacetyl, benzoin, benzyl, anthraquinone, acetophenone, diphenyldisulfide, benzophenone and derivatives thereof can be mentioned, but when any of the aforementioned conventional photosensitizers are used in the present invention, completion of the polymerization reaction is not possible and a considerable amount of the nonreactive monomer remains, and as a result, tackiness is observed at the time of water absorption by the water-absorbent composite material formed, and furthermore, in general, the aforementioned photosensitizer is harmful to the body and the resulting material is not suitable for use in sanitary products.

In specific terms, production of the present invention is conducted according to the method described below. First, an alkaline metal salt of an acrylic acid, a divinyl-based compound and other optional monomer components that may be used are each added to water at the predetermined ratios to be dissolved and to produce an aqueous solution of the monomer. It is desirable when formulation is done in such a manner that a monomer concentration in the

range of approximately 25-65 wt%, preferably in the range of 30-60 wt%, is achieved, and a temperature of the aforementioned aqueous solution of approximately 0-40°C, preferably in the range of 10-25°C, is maintained. In this case, when the monomer concentration achieved is less than 25 wt%, the degree of polymerization of the water-absorbent resin is likely to be reduced; on the other hand, when the concentration exceeds 65 wt%, the temperature of the reaction system becomes too high at the time of the reaction and, as a result, the material suitable to be used for the base material becomes limited or the water-absorbent resin formed is likely to become a porous material, and furthermore, a material with high moisture retention is less likely to be formed. Furthermore, when the liquid temperature of the aforementioned aqueous solution is below 0°C, coagulation of the aqueous solution occurs; on the other hand, when the temperature exceeds 40°C, the temperature in the reaction system becomes too high and a porous water-absorbent resin with a lower degree of moisture retention is likely to be formed, and neither case is desirable.

Furthermore, the aforementioned specific photosensitizer is added to the aforementioned aqueous solution of a monomer and mixed to dissolve the photosensitizer. The amount of the photosensitizer used in this case is not especially limited, and in general, is suitably in the range of approximately 0.001-5.0 wt%, preferably in the range of 0.01-1.0 wt%, for the entire amount of the monomer. Furthermore, in addition to the aforementioned photosensitizer, a water-soluble polymerization initiator such as potassium persulfate may be added during the course of the reaction. Subsequently, the aforementioned liquid mix is adsorbed onto the surface of the base material. For the base material, conventional materials used for this purpose can be used in this case as well, and from the standpoint of flexibility, air permeability, etc., of the water-absorbent composite material, woven cloths made of synthetic resin fibers or natural fibers, and fibrous base materials made of nonwoven fabrics, webs, paper, wadding materials, etc., are suitable. The basis weight of the base material when a fibrous base material is used is not especially limited but, in general, a basis weight in the range of approximately 10-500 g/m^2 is suitable. The method used for adsorbing the aforementioned liquid mix onto the base material is not especially limited, and for example, spray coating using a spray nozzle, etc., or coating using a curtain flow coater, etc., can be used, and in this case, the base material can be fed continuously or batch-wise, as desired. The adsorption ratio of the aforementioned liquid mix varies depending on the type of the base material used and the intended application of the water-absorbent composite material finished product, and is suitably an amount that does not cause loss of the air permeability of the base material, that is, an amount that does not cause formation of a continuous film of the water-absorbent resin on the base material, and in general, an adsorption ratio in the range of approximately 10-300 g/m^2 is suitable in terms of the solid parts conversion of the resin. When the adsorption ratio is lower than 10 g/m^2, the water-absorbency of the composite material

becomes insufficient; on the other hand, when the adsorption ratio exceeds 300 g/m^2, the air permeability or flexibility of the composite material obtained is likely to be lost and the surface area of the water-absorbent resin included in the composite material is reduced, and as a result, the water-absorbency is reduced and either case is undesirable. A suitable adsorption ratio is in the range of approximately 10-150 g/m^2. When the liquid mix is adsorbed onto the base material, a part of the liquid mix is impregnated into the surface area of the base material, but it does not pose any special problems, and in this case, adhesion between the water-absorbent resin and the base material can be reinforced.

Furthermore, ultraviolet rays are applied to the liquid mix adsorbed onto the surface of the base material, and polymerization and cross-linking reactions are initiated. When the adsorption ratio of the liquid mix is within the aforementioned range, ultraviolet rays are adequately transmitted into the liquid mix adsorbed. When a base material such as a woven cloth, a nonwoven fabric, a web, a paper or a wadding material that can be readily applied in a continuous process is used in the present invention, adsorption of the liquid mix, the polymerization reaction and the cross-linking reaction of the liquid mix can be easily automated. As a result, formation of the target water-absorbent composite material can be done continuously with high production efficiency. The luminous energy of the ultraviolet rays used in the present invention is not especially limited and, in general, an energy density in the range of approximately 20-3500 mJoule/cm^2 is suitable. When the energy density applied is below the lower limit, the polymerization and cross-linking reactions are likely to be insufficient, and when the energy density applied exceeds the upper limit of the aforementioned range, rupturing of the cross-linked structure occurs after the polymerization and cross-linking as a result of the excessive energy applied, and materials with a low molecular weight become tacky in some cases, and the result is not desirable. A desirable luminous energy density is in the range of approximately 200-2000 mJoule/cm^2. Furthermore, as for the light source used for the ultraviolet rays, any conventional light sources, for example, a mercury lamp, a metal halide lamp, etc., can be used. The radiation wavelength used in this case is not especially limited and, in general, light with a wavelength in the range of 200-450 nm can be used effectively. Upon application of the ultraviolet rays, the reaction is initiated immediately. The radiation time is determined appropriately to form the aforementioned luminous energy density, and for example, when radiation is applied to a material placed on an endless belt, in general, the polymerization reaction and cross-linking reaction can be completed when the material is passed through the irradiation area and is exposed for a period of approximately several seconds to several minutes under the aforementioned conditions, and the aforementioned water-absorbent resin can be effectively adsorbed onto the base material. In this case, the maximum temperature reached inside the reaction system is retained in the range of 60-70°C as long as the concentration of the

aforementioned monomer and the temperature of the aqueous solution of the monomer are adjusted to be within the aforementioned ranges, with no formation of air bubbles from the water included due to the heat from reactions such as the polymerization reaction, so the usual resultant formation of a porous resin does not occur.

In this manner, production of the water-absorbent composite material can be achieved efficiently. The water-absorbent composite material obtained exhibits excellent water-absorbent characteristics such as good water-absorbency and a high water-absorption rate as is, and when a further increase in the water-absorption rate is required, the aforementioned purpose can be achieved when an aqueous solution of a cross-linking agent is further adsorbed onto the surface and drying is done under heat after the aforementioned polymerization reaction and the cross-linking reaction with ultraviolet rays. In other words, in general, an aqueous solution of a cross-linking agent, composed of a cross-linking agent containing two or more functional groups capable of reaction with carboxylate groups included in the water-absorbent resin of the water-absorbent composite material obtained above and water, is adsorbed onto the water-absorbent composite material using the spraying method, etc., and subsequently dried at a temperature in the range of approximately 40-80°C; as a result, an increase in the water-absorption rate can be achieved, and furthermore, the surface of the water-absorbent composite material can be modified. For the aforementioned cross-linking agent, for example, glycidyl ether-based compounds such as ethylene glycol diglycidyl ether and polyethylene glycol diglycidyl ether, water-soluble polyhydric metal salts such as magnesium sulfate, aluminum sulfate and aluminum chloride, haloepoxy-based compounds such as epichlorohydrin and α-methyl chlorohydrin, etc., can be mentioned. Among those listed above, glycidyl ether-based compounds are especially desirable in this case. Furthermore, in general, the amount of the cross-linking agent used is in the range of approximately 0.001-5.0 wt%, preferably, in the range of 0.01-1.0 wt%, for the water-absorbent resin included in the aforementioned water-absorbent composite material. As long as the amount of the cross-linking agent is within the aforementioned range, the concentration of the aqueous solution of the cross-linking agent is not limited, and adjustment of the concentration can be carried out appropriately. Furthermore, it is possible to add a surfactant to the aforementioned aqueous solution of the cross-linking agent. The surfactant used in this case is not especially limited, and when the intended application of the water-absorbent composite material obtained is for sanitary products, etc., in general, use of a sorbitan fatty acid ester, a saccharose fatty acid ester, etc., is desirable from the standpoint of safety, sanitation and considerations such as skin irritation.

In the water-absorbent composite material produced according to the method of the present invention, a water-absorbent resin made of a transparent rubber-like elastic material is bonded firmly to the base material. In general, the water-absorbent resin is granular, and the

percentage of moisture content is in the range of approximately 35-75 wt%, and adjustment of the moisture content can be made easily possible through drying, as needed. For the machine used for drying, conventional machines, for example, hot-air dryers, infrared dryers, fluidized-bed dryers, etc., can be used and, in general, the drying temperature used is in the range of approximately 70-200°C.

The water-absorbent composite material produced according to the method of the present invention is cut to a desired size, shaped to a desired shape, and fabricated into a desired product according to the application purpose, and can be easily formed into a product. The water-absorbent composite material produced as explained above can be used for the aforementioned variety of applications, and the composite material can be used effectively for sanitary products such as sanitary napkins and disposable diapers.

Effect of the invention

According to the method of the present invention, the exceptionally desirable effects listed below can be achieved.

(1) In the production of an acrylate-based polymer cross-linked material, a solution polymerization reaction based on ultraviolet rays is made possible for the first time, thus making possible the continuous production of a water-absorbent resin utilizing a process that easily accommodates automation of adsorption of the liquid mix onto the base material and application of ultraviolet rays and an increase in production efficiency.

(2) The type of base material used is not limited, since the temperature used for production processes such as the polymerization reaction is low.

(3) Production of a water-absorbent composite material having excellent flexibility and air permeability can be easily achieved.

(4) The water-absorbent resin included in the water-absorbent composite material obtained has a large surface area and has excellent water absorption and furthermore, no porous structure is present and a very high water-retention performance and water-holding capacity can be achieved; thus, when used for a sanitary product, high retention of urine or blood can be effectively achieved.

(5) Furthermore, the polymerization reaction and the cross-linking reaction are thoroughly completed and the water-absorbent resin included in the water-absorbent composite material contains almost no material with a low molecular weight; as a result, tackiness at the time of water absorption hardly exists.

Application examples

The method of production of the present invention is explained in specific terms with the reference examples and application examples below, but the present invention is not limited by the examples shown below.

Reference Example 1

First, 136.55 g (corresponding to 75 mol% for acrylic acid) of sodium hydroxide were added to 328 g of acrylic acid and 543.2 g of water to neutralize while chilling in ice; then, 0.040 g (0.01 wt% for the total monomer content) of N,N'-methylenebisacrylamide (hereinafter referred to as MBAM) and 0.403 g (0.1 wt% for the total monomer content) of 2,2'-azobis(N,N'-dimethyleneisobutylamidine)-2-hydrochloride (Product of Wako Pure Chemical Ind. Co. (Ltd.), trade name "VA-044") were added to be dissolved, furthermore, nitrogen gas was blown into the system and purging of dissolved oxygen was carried out, and the liquid temperature was adjusted to 20°C to produce formula A having a total monomer concentration of 40 wt%.

Reference Example 2

From Reference Example 1, the amount of water used was changed to 687.15 g and production of formula B having a total monomer content of 35 wt% was achieved in the same manner.

Reference Example 3

First, 243.66 g (corresponding to 72 mol% for acrylic acid) of potassium hydroxide were added to 434.58 g of acrylic acid and 321.9 g of water to neutralize while chilling in ice; then, 0.060 g (0.01 wt% for the total monomer content) of MBAM and 0.300 g (0.05 wt% for the total monomer content) of "VA-044" were added to be dissolved; furthermore, nitrogen gas was blown into the system and purging of dissolved oxygen was carried out, and the liquid temperature was adjusted to 20°C to produce formula C having a total monomer concentration of 60 wt%.

Reference Example 4

From Reference Example 1, 0.403 g (0.1 wt% for the total monomer content) of 2,2'-azobis(2-amidinopropane)-2-hydrochloride (product of Wako Pure Chemical Ind. Co. (Ltd.) tradename "V-50") was used instead of "VA-044," and production of formula D was carried out in the same manner.

Reference Example 5

0.10 g of ethylene glycol diglycidyl ether was added to 70 g of water to be dissolved, and production of a solution containing a cross-linking agent was carried out.

Application Example 1

First, 4.28 g of formula A produced in Reference Example 1 above were uniformly sprayed onto a commercial polyester web with dimensions of 15 cm x 38 cm and a basis weight of 30 g/m^2 to form an adsorption ratio of 30 g/m^2 in terms of solid resin conversion; then, ultraviolet rays were applied by means of a conveyor-type ultraviolet curing machine (Product of Eye Graphic Co. (Ltd.)) (high-pressure mercury lamp 2 kW x 2 lamps, 80 W/cm, principal luminous wavelength 250 nm) under a belt transport speed of 10 m/min and radiation time of 10.8 sec to achieve a luminous energy density of 900 mJoule/cm^2, and a water-absorbent composite material in which a spherical hydrated gel-like cross-linked polymer having rubber elasticity was adsorbed onto the fibers was produced.

Application Examples 2-10

From Application Example 1, at least one factor among the formula used, the amount of formula used, adsorption ratio of the formula and base material used was changed as shown in Table 1 below, ultraviolet rays were applied in the same manner, and production was carried out for a variety of water-absorbent composite materials in which spherical hydrated gel-like cross-linked polymers having rubber elasticity were adsorbed onto the fibers in the same manner.

Table 1

1 実施例	2 モノマー調製液		3 付着量	4 基材（15cm×38cm）	
	5 種類	6 使用量（g）	（g／㎡）	7 坪量（g／㎡）	5 種類
1	A	4.28	30	30	ポリエステル製ウエブ 8
2	A	7.13	50	30	ポリエステル製ウエブ
3	A	10.00	70	30	ポリエステル製ウエブ
4	B	11.40	70	30	ポリエステル製ウエブ
5	C	6.65	70	30	ポリエステル製ウエブ
6	D	10.00	70	30	ポリエステル製ウエブ
7	A	10.00	70	150	綿状パルプ 9
8	A	4.28	70	13	ティッシュペーパー 10
9	A	10.00	70	35	木綿製ガーゼ 11
10	A	10.00	70	30	ポリプロピレン製不織布 12

Key:
1 Application Example _____
2 Monomer formula
3 Adsorption ratio (g/m^2)
4 Base material (15 cm x 38 cm)

5 Type
6 Amount used (g)
7 Basis weight (g/m^2)
8 Polyester web
9 Cotton pulp
10 Tissue paper
11 Cotton gauze material
12 Polypropylene nonwoven fabric

Application Example 11

0.56 g (14 wt% for the resin) of the aqueous solution containing a cross-linking agent produced in Reference Example 5 was sprayed onto the composite material produced in Application Example 3; then, drying was carried out for 20 min at a temperature of 70°C so as to produce a water-absorbent composite material.

Application Example 12

0.56 g (14 wt% for the resin) of the aqueous solution containing a cross-linking agent produced in Reference Example 5 was sprayed onto the composite material produced in Application Example 7; then, drying was carried out for 20 min at a temperature of 70°C so as to produce a water-absorbent composite material.

Application Example 13

0.24 g (14 wt% for the resin) of the aqueous solution containing a cross-linking agent produced in Reference Example 5 was sprayed onto the composite material produced in Application Example 8; then, drying was carried out for 20 min at a temperature of 70°C so as to produce a water-absorbent composite material.

Application Example 14

0.56 g (14 wt% for the resin) of the aqueous solution containing a cross-linking agent produced in Reference Example 5 was sprayed onto the composite material produced in Application Example 9; then, drying was carried out for 20 min at a temperature of 70°C so as to produce a water-absorbent composite material.

Application Example 15

0.56 g (14 wt% for the resin) of the aqueous solution containing a cross-linking agent produced in Reference Example 5 was sprayed onto the composite material produced in

Application Example 10; then, drying was carried out for 20 min at a temperature of 70°C so as to produce a water-absorbent composite material.

Application Example 16

From Application Example 3, the luminous energy was changed to 1500 $mJoule/cm^2$ (the ultraviolet irradiation time was 18 sec) and the treatment was carried out as described above to produce a water-absorbent composite material.

Furthermore, performance of water-absorbent composite materials produced in the aforementioned application examples was examined according to the test methods explained below.

Method for testing the performance of water absorptive composite material

O Water-absorbency

A sample water-absorbent composite material cut to a size of 10 cm x 10 cm was placed inside a tea bag made of a 250-mesh nylon net and soaked in a saline solution for 1 h, drained for 15 min, then the weight [a] g was measured. Furthermore, the aforementioned treatment was carried out for a tea bag without a sample and the weight [b] g was measured in the same manner, and the saline solution absorption ratio was calculated according to the formula shown below.

Saline solution absorption ratio (g/m^2) = ([a] - [b]) x 100

O Water-retention capacity

After measurement was completed by the tea bag method, centrifugal dehydration was carried out with a centrifugal dehydrator of Kokusan Centrifugal Machines Co. (Ltd.) (Model H-120A) at 6.5 on the dehydrator scale at 600 rpm and weight [a] g was measured. Furthermore, a tea bag without the sample was used and the aforementioned measurement was carried out and weight [b] g was measured, and the water-retention capacity was calculated according to the equation shown below.

Water-retention capacity (g/m^2) = ([a] - [b]) x 100

O Water-retention performance

Water-retention performance was calculated according to the equation shown below.

Water-retention factor (%) = Water-retention ratio/water-absorption ratio x 100

O Water-absorption rate

A water-absorbent composite material with a measurement of 6 cm x 6 cm was placed in a glass dish having a diameter of approximately 9 cm; then, 10 g of a 0.9% saline solution were added. When the saline solution in the aforementioned dish was visually judged as being

absorbed by the composite material, the dish was tilted 45° and dripping of the saline solution from the composite material was examined. When complete adsorption was achieved, the dish was returned to the horizontal state and the aforementioned process was repeated. The amount of time starting when the saline solution was first added to the time that dripping of the saline solution stopped was measured and used as the evaluation of the water absorption rate.

The aforementioned test results and the thermal deformation state of the base material are shown in Table 2 below.

Table 2

① 供試複合体	② 吸水能 (g/㎡)	③ 保水能 (g/㎡)	④ 保水率 (%)	⑤ 吸水速度 (秒)	⑥ 熱変形状態
⑦ 実施例1	4580	4030	88	–	変化なし ⑧
実施例2	6220	5410	87	–	変化なし
実施例3	8810	7840	89	51	変化なし
実施例4	7270	6620	91	–	変化なし
実施例5	8900	7830	88	–	変化なし
実施例6	7850	7070	90	–	変化なし
実施例7	6830	5260	77	45	変化なし
実施例8	2240	1950	87	55	変化なし
実施例9	2880	2100	73	41	変化なし
実施例10	3130	2700	86	48	変化なし
実施例11	7040	5510	78	38	変化なし
実施例12	5330	3540	66	30	変化なし
実施例13	1800	1300	72	40	変化なし
実施例14	1920	1250	65	29	変化なし
実施例15	2130	1680	79	36	変化なし
実施例16	8800	7820	89	–	変化なし

Key:
1 Sample composite material
2 Water-absorbency (g/m^2)
3 Water-retention performance (g/m^2)
4 Water-retention factor (%)
5 Water absorption rate (sec)
6 Thermal decomposition state
7 Application Example ___
8 No change observed

Table 2 (cont.)

① ブランク（基材）	② 吸水能 (g/㎡)	③ 保水能 (g/㎡)	④ 保水率 (%)	⑤ 吸水速度 (秒)	⑥ 熱変形状態
⑦ ポリエステル製ウエブ	1990	720	36		
綿状パルプ ⑧	3260	1030	32		
テイツシユペーパー ⑨	1200	360	30		
木綿製ガーゼ ⑩	960	280	29		
⑪ ポリプロピレン製不織布	1220	390	32		

Key:
- 1 Blank (base material)
- 2 Water-absorbency (g/m^2)
- 3 Water-retention performance (g/m^2)
- 4 Water-retention factor (%)
- 5 Water-absorption rate (sec)
- 6 Thermal decomposition state
- 7 Polyester web
- 8 Cotton pulp
- 9 Tissue paper
- 10 Cotton gauze material
- 11 Polypropylene nonwoven fabric

As clearly shown in Table 1 [sic; Table 2], very high water-absorbency, water retention performance and water-absorption rate can be achieved in each water-absorbent composite material produced according to the method of the present invention. Furthermore, the composite materials produced in Application Examples 11-15 have a superior water-absorption rate to those of the composite materials produced in Application Examples 3, 7, 8, 9 and 10.

In addition, tackiness at the time of water absorption was absent in each of the aforementioned water-absorbent composite materials.